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Does musical training improve school performance?

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Abstract In a retrospective study, we compared school performance of 53 children practicing music (group 1) with 67 controls not practicing music (group 2). Overall average marks as well as average marks of all school subjects except sports were significantly higher in children who do (group 1) than in those who do not practice music (group 2). In a multiple regression analysis, musical training, parent's income, and educational level (grades) correlated significantly with overall average marks. A slight decrease of overall average marks over 4 years from grades 3 to 6 was found in the control group only. Musical training evidently correlates with children's better performance at school, but is obviously part of a multifactorial dependence. Continuous musical training appears to help achieve and maintain school performance at a high level over time.

Keywords Music · Musical training · School performance · Mark · Marks · Grade · Grades

Music processing and playing instruments are related to activity in many different areas of the brain (Gaser and Schlaug 2003; Koelsch et al. 2005; Koelsch and Siebel 2005). On an anatomical level, it has been shown that musicians, compared to non-musicians, tend to have (at least relatively) enlarged structures in certain areas of the brain, as for instance the

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left planum temporale or the cerebellum (Gaser and Schlaug 2003; Hutchinson et al. 2003; Schlaug et al. 1995a, b). Two studies have suggested that this enlargement of cerebral structures might have implications on cognitive functions (Chan et al. 1998; Ho et al. 2003).

In a study which involved random assignment, Schellenberg (2004) even found a positive overall effect of musical training on IQ scores in school children. In 2006, the same author reported positive associations between the duration of music lessons and IQ scores as well as between music lessons and academic performance. These very general associations found in a Torontonian sample of volunteers mark the starting point for our study. We want to find out if (a) Schellenberg's findings can be validated with a representative sample of Bernese (Swiss) children; (b) if musical training is associated with better overall school performance in grades 3 to 6; (c) if this effect is domain-specific or if it is rather general and extending over several school subjects and (d) if the association of music and school performance disappears if socio-economic factors are taken into account as well. In order to provide an in-depth analysis of school performance and thus extending the findings by Schellenberg (2006), we evaluated average marks per school subject in addition to overall average marks. Data of four different grades were analyzed in order also to estimate the association between the duration of musical training and school performance.

Methods

In this non-randomized retrospective cross-sectional study, teachers of two school centers in the city and suburbs of Bern, Switzerland, were asked to copy the annual reports of the average marks of all the children in their respective classes. The age of the children varied according to their grade. Average IQ levels of the children were not available. The duration and intensity of musical training could not be evaluated for groups of children or single cases. Overall average marks and average marks of various school subjects were compared between children with and without musical training as confirmed by their teachers. Teachers told us to be absolutely sure whether a child practices music or not. This knowledge is based on self-reports from and discussions with the children as well as on talks with their parents. Variables used for statistical analysis are specified in Table 1.

Of the two school centers, teachers of seven classes with a total of 134 children participated. The data for all children in the respective classes have been collected anonymously by their teachers. Thus, in order to avoid biased results, the sample is not based on individual subjects' choice to participate or not and is representative for this age group in the region of Bern. Table 2 contains details on the sample. One hundred and thirty-four children were divided into three groups. Those practicing music at home and at school were assigned to group 1 ($n = 53$). Most participants of group 1 took piano lessons regularly. Group 1 was therefore not further divided into subgroups depending on their favourite instrument. Those who did not practice music and did not do handicrafts formed group 2 ($n = 67$). Fourteen children taking optional lessons in handicraft but not in music were assigned to group 3.

The school subjects were the languages German and French, mathematics, history/natural history/geography combined in one subject, handicraft (lessons in working with wood and textiles, drawing and painting), music and sports. Of these subjects, we collected the complete data from all 134 children. French lessons do not start before the fifth grade; therefore only 69 pupils received tuition in French.

Table 1 Collected variables

Variable name	Description
Grade	Grades range from 3rd to 6th in the Swiss system, roughly corresponding to 3rd to 6th grade in the American system.
Gender	Female and male.
Income	Indicates the monthly parental income in Swiss Francs. This information was available for 124 out of 134 participants (93%). The numbers reflect the average income of the parent's profession according to the Swiss Federal Statistical Office.
Music	Indicates whether the child plays and practices an instrument and takes extracurricular lessons as confirmed by their teachers.
Handicraft	Indicates whether the child takes optional handicraft lessons at school.
Overall average marks	Indicates the marks averaged over all subjects irrespective of the child's grade.
Average marks	Marks per subject. Subjects at school were German, French, mathematics, history/natural history/geography, handicraft, music and sports. Marks range from 1 (worst) through 4 (sufficient) up to 6 (best).

Table 2 Participants

Grade	Average age (years)	Total (n)	Female/male (n)	Playing an instrument (n; %)	Optional handicraft (n; %)
3	9	45	21/24	23; 51.1	0; .0*
4	10	18	7/11	8; 44.4	0; .0*
5	11	34	12/22	10; 29.4	4; 11.8
6	12	37	19/18	12; 32.4	10; 27.0
Summary	10.5	134	59/75	53; 39.6	14; 10.4

* Optional handicraft lessons cannot be taken in the 3rd and 4th grade

The student's *t* test (two-tailed) was used to compare overall average marks and average marks for various subjects between the three groups. For more than four *t* test calculations, the Bonferroni-Holm-procedure was applied. School performance may not only be influenced by musical training or extra lessons in handicraft, but also by a great variety of environmental factors. Therefore, the correlation of average marks with various predictors was tested using multiple linear regression analysis. This method assesses the significance of individual predictor variables for a criterion variable while the other predictors are held constant. The socio-economic situation of the children has been shown to be one such predictor (Björklund et al. 2003; Kozhaya and Cowley 2005). Thus, we included the parent's average income. According to Lee et al. (2003) and Luders et al. (2004), gender appears to be a variable modifying the effect of musical training on the development of certain neuronal connections and was accordingly included in the analysis as well. Finally, the educational level (grade) of the pupils entered the analysis as school performance in different subjects might vary with increasing age of the pupils.

Results

Overall average marks (means, standard errors and standard deviations) of all 134 children irrespective of their grade are shown in Fig. 1. Children playing an instrument (group 1) achieved significantly better average marks at school than controls (group 2, $t(118) = 4.47$, $p < .001$). Children taking optional handicraft lessons (group 3) received significantly worse average marks at school than controls with $t(79) = 2.51$, $p < .05$.

Subsequently, we looked at the average marks per school subject to identify in which subjects the children playing an instrument performed better than controls. Average marks per school subject and standard deviations are shown in Fig. 2. Children playing an instrument were significantly better than controls in all subjects except in sports. The

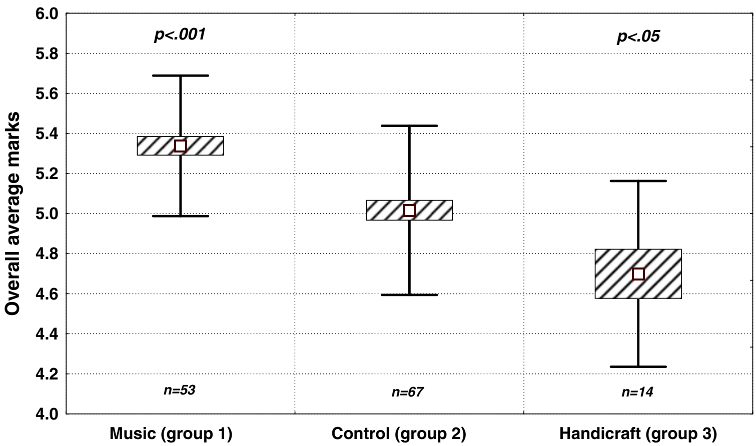

Fig. 1 Comparison of overall average marks of pupils practicing music (left) and of pupils doing handicrafts respectively (right) with those who neither practice music nor do handicrafts (middle). Means (squares), standard errors (boxes), standard deviations (bars)

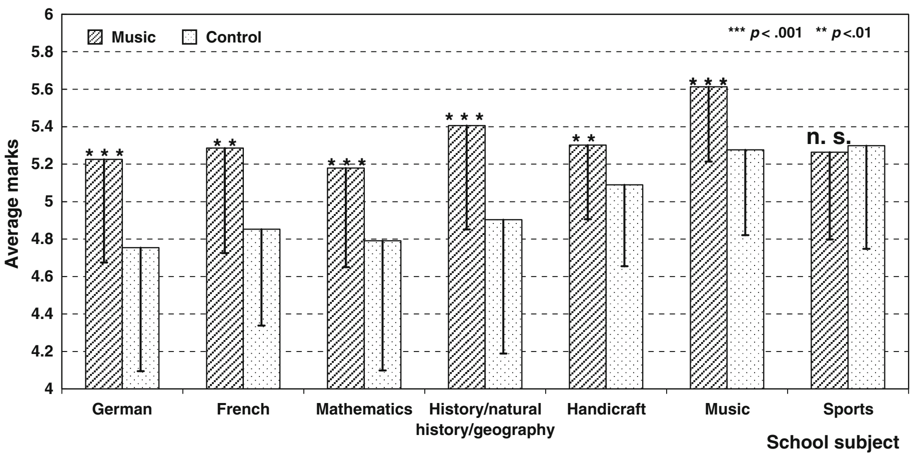

Fig. 2 Average marks (means and standard deviations) for grades 3–6; pupils practicing an instrument (music) versus others (control)

Table 3 Multiple regression analysis of overall average marks

Variable	Beta	Partial correlation	t	p
Grade (educational level)	−.404	−.466	−5.762	<.001
Parent's income	.330	.395	4.713	<.001
Music	.280	.339	3.950	<.001
Gender	.123	.159	1.760	=.081
Handicraft	−.099	−.119	−1.310	=.193

n = 134; R = .654; R^2 = .428

average marks for all school subjects varied between 5.2 ± .6 and 5.4 ± .6 in group 1 and between 4.8 ± .7 and 5.3 ± .6 in group 2. Two-tailed t tests revealed statistically significant differences with $p < .01$ for the subjects French and handicraft and $p < .001$ for the subjects German, music and history (for details, see Appendix). To take into account that we conducted seven t tests (one per school subject), we applied the Bonferroni-Holm-procedure which lowers the minimal p required for a significant result from .05 to .0073. However, all significant p values from our t tests are far below this adjusted level of significance.

As mentioned in the methods section, we conducted a multiple linear regression analysis in order to evaluate the potential effect of factors other than musical training on school performance. We entered gender, grade, parent's income, music and handicraft as predictor variables and overall average marks as criterion variable. Grade and parent's income reach the highest partial correlations. But, interestingly, the predictor music still proves highly significant after the other predictors are held constant (Table 3). After exclusion of the non-significant variables gender and handicraft, the three significant predictor variables remaining in the regression accounted for 43% of the variance of the overall average marks at school.

If the duration of musical training would be of any influence on school performance, its effect should increase with higher educational level of the pupils. If the child started very recently, there should be little or no effect on the marks, whereas if the child already played for several years, the effect should be more significant. If we only consider the data from the children in the third grade, the overall average marks received by children playing an instrument ($M = 5.42$, $SD = .31$) do not significantly differ from the ones achieved by controls ($M = 5.33$, $SD = .37$) with $t(43) = .88$, $p = .383$. However, if we consider the data from the children in the sixth grade only, the overall average marks received by children playing an instrument ($M = 5.21$, $SD = .41$) are significantly higher than the ones received by controls ($M = 4.80$, $SD = .45$) with $t(25) = 2.48$, $p < .05$. From the fourth grade on, children playing an instrument (group 1) achieved significantly better overall average marks than controls (group 2). The overall average mark values in grades 3 and 6 of group 1 were comparable, i.e. 5.42 and 5.21 with $t(33) = 1.66$, $p = .106$. By contrast, the respective values in control group 2 differed significantly (5.33 in grade 3 and 4.80 in grade 6 with $t(35) = 3.90$, $p < .001$) as illustrated in Fig. 3.

Discussion

During the past 15 years, the impact of music on performance in verbal and sensorimotor tasks has been controversially discussed. Rauscher et al. (1993) reported that simply

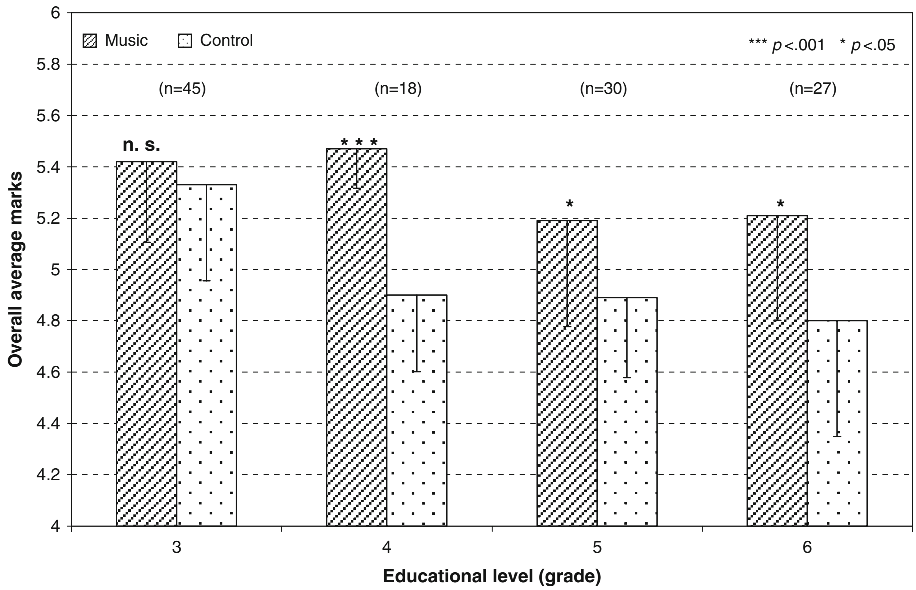

Fig. 3 Overall average marks (means and standard deviations) per educational level

listening to a Mozart sonata improved participants' performance in spatial tasks; similar results were also found for children (Rauscher et al. 1997). These findings could not always be replicated and are still controversial (see e.g. Steele et al. 1999; Schellenberg 2006). Our study, however, goes into another direction. We analyzed if continuous, active involvement with music over a longer period is associated with better school performance. Our data are therefore to be seen in line with those by Schellenberg (2006), who argued for a dose-response relationship between musical training and intellectual performance. Our results are in agreement with those by Schellenberg (2006) in that we find a significant association between continuous musical training and general intellectual performance at school for children between 9 and 12 years of age.

Since some areas of the brain are involved in both processing of music and language (e.g. Koelsch 2005), it might seem conceivable that, on a neurophysiological basis, a "special link" exists between musical activity and (for example) language skills. Such a link or influence was for example postulated by Chan et al. (1998) or Ho et al. (2003). Our data, however, bear no evidence for such theories. Our effect in the average marks spreads across all subjects (except sports), which rather speaks for an overall, non-specific association of musical training and intellectual performance. Similar patterns show up when intellectual performance is measured using IQ tests instead of school performance. Schellenberg (2004) measured the IQ of first-grade children who attended music lessons and those who received drama lessons or no lessons. After 1 year of musical training, a slightly larger increase of full-scale IQ was observed than in the control group. The author concluded a "modest but widespread intellectual benefit from taking music lessons"; a statement which would perfectly fit to our data patterns as well, although our design does not allow for causal inferences.

Our data further bear evidence that it is actually the duration of musical training which is relevant. In the third grade, where children can be expected to have had but little musical training, there is no significant difference in school performance between such who play an instrument and such who do not. In later grades (e.g. grade 6), where it is most likely that children have had more musical training so far, school performance in the "music" group is significantly higher (Fig. 3). Thus, we were able to validate Schellenberg's (2006) finding of a dose-response relationship between music lessons and intellectual abilities with a representative sample of another culture. The slight decrease of average marks from grade 3 to grade 6 visible in the same figure can, according to teachers' statements, be explained by the increasing general pressure and stress of performance at school. The older the children get, the more difficult it is for them to achieve good marks because requirements and pressure at school increase steadily. Yet, children with musical training maintained a better school performance during a period of 4 years than controls without musical training.

The association between musical training and school performance that we found in our study could be interpreted in different ways. Firstly, young children with a high IQ and above-average performance at school might be more motivated to learn to play an instrument. Secondly, the socio-economic environment may influence the disposition for musical training. Finally, continuous music lessons may improve school performance in general.

In order to discuss the first possible interpretation, we resort to the findings by Norton et al. (2005). They argued that there are no significant pre-existing or initial neural, cognitive, motor, or musical differences between children who choose to learn an instrument and such who do not, although the means reached by the children who chose to learn an instrument were higher in almost all tasks compared to controls. With respect to these results, it could be speculated that musical training exaggerates possible pre-existing differences and renders them significant, although we could not sample any relevant data in this respect.

The second option, namely that children of more affluent parents can more likely afford extracurricular music lessons and thus, only because of their socio-economic background, are those who potentially perform better in school, seems plausible. It has for example also been shown that more educated parents with higher socio-economic status are more actively involved in the management of their child's educational achievement (Baker and Stevenson 1986). We therefore included parent's income as a first approximation to the socio-economic environment in our multiple regression analysis. This predictor turned out to have a highly significant impact on school performance. However, musical training retained statistical significance when income was held constant. Interestingly, a one-tailed Mann–Whitney U test revealed no significant difference ($p = .08$) in parent's income between children who practice music and those who do not. Whether additional hitherto unknown variables are active in the association between musical training and intellectual performance at school needs to be investigated further.

There are many points that would speak for the third explanation (music lessons positively influencing school performance). Perceiving music activates cerebral regions such as the inferior fronto-lateral and posterior temporal cortex that are also involved in the processing of languages (cited from Koelsch 2005). A study by Kilgour et al. (2000) revealed that spoken or sung lyrics were better memorized by undergraduates with music training compared to those without. Koelsch (2005) stated that music and speech are intimately connected in early life, due to neural activity of overlapping cerebral regions. Cheek and Smith (1999) found that ninth-grade students who received private keyboard instruction for at least 2 years in addition to music lessons at school achieved significantly better mathematic scores than students without private music lessons. It seems to us that researchers have found positive results in whatever domain they were investigating, be it language skills or mathematical skills. These findings, together with our results, strongly support the notion that being engaged with music is associated with general cognitive or intellectual functions and that "special links" to single school subjects do not exist. In our data, this is reflected by better performance throughout all "intellectual" subjects.

Neuroanatomical studies might give us an idea about how the association between musical training and intellectual performance could come about. Musical training is associated with an augmentation of gray matter in several areas of the primary motor cortex, the superior parietal cortex (Gaser and Schlaug 2003), the anterior superior temporal gyrus predominantly of the left hemisphere (Koelsch et al. 2005) and the cerebellum (Gaser and Schlaug 2003; Hutchinson et al. 2003). The results based on functional magnetic resonance imaging were interpreted as processes facilitating subtle sensorimotor demands during musical training. In another study, a larger fiber volume in the anterior corpus callosum was argued to represent intensified interhemispherical transferral but this effect was found in male individuals only (Lee et al. 2003). Gender differences in processing music have been described in at least two studies (Koelsch et al. 2003a, b). However, in our multiple linear regression, gender did not significantly contribute to the variation of overall average marks.

In summary, musical training and additional factors such as educational level of the pupils (grades 3–6) and parent's income tested in a multiple regression analysis proved to be significantly correlated with school performance. Nevertheless, in combination with all these factors, musical training remained a predictor of high statistical significance, although partial correlations of the predictors grade and parent's income with the criterion variable were even higher. By contrast, taking additional handicraft lessons instead of practicing music did not significantly correlate with overall average marks.

Brains of individuals practicing music have been shown to undergo use-dependent structural variations during a critical period of brain maturation (Gaser and Schlaug 2003; Norton et al. 2005; Schlaug et al. 1995b). Therefore, music is likely to mean more for children than just a way to have fun. It appears to induce structural and functional variations of certain regions of the brain resulting in manifold implications. A study by Schlaug et al. (1995b) suggested that an introduction to musical training earlier than age 7 is crucial to the development of brain structures. In consequence, it makes sense to take advantage of this period of high brain plasticity and to promote an early beginning of musical training for children. Further implications might evolve about the communicative, emotional and social, as well as genetic, aspects of making music.

At present, funding for music education is often reduced in order to save money. Music and arts are sometimes regarded as a luxury and as being of lesser significance for a child's education than other subjects such as mathematics or languages. We believe that such thinking is not justified because music is an important part of our culture and its exertion both involves many different skills and activates several areas of the brain. We believe that there are strong reasons why music has been our true companion for thousands of years—until now, only some of these reasons and their implications have been discovered.

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Appendix Average marks of children practicing music and controls

School subject	Music (mean ± SD)	Control (mean ± SD)	*t*	df	*p*
German	5.2 ± .6	4.8 ± .7	4.189	118	<.001
French	5.3 ± .6	4.9 ± .5	2.926	53	<.01
Mathematics	5.2 ± .5	4.8 ± .7	3.378	118	<.001
History/natural history/geography	5.4 ± .6	4.9 ± .7	4.216	118	<.001
Handicraft	5.3 ± .4	5.1 ± .4	2.762	118	<.01
Music	5.6 ± .4	5.3 ± .5	4.250	118	<.001
Sports	5.3 ± .5	5.3 ± .6	.363	118	=.717

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